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A Programme to Control Taeniosis-Cysticercosis (*Taenia solium*) in Mexico

Aline S. de Aluja¹, Julio Morales Soto² and Edda Sciutto³

¹*Departamento de Patología, Facultad de Medicina Veterinaria y Zootecnia, Universidad Nacional Autónoma de México, Ciudad Universitaria, D. F.,*

²*Lab. MVZ. Aline S. de Aluja, Facultad de Medicina Veterinaria y Zootecnia, Universidad Nacional Autónoma de México, Ciudad Universitaria, D. F.*

³*Lab. de Inmunología, Instituto de Investigaciones Biomédicas, Universidad Nacional Autónoma de México, Ciudad Universitaria, D. F. Mexico*

1. Introduction

Taenia solium cysticercosis is a zoonosis which affects animals, mainly pigs, and human beings.

In pigs the cysticerci are found both in muscles and in the brain, in human beings predominantly in the form of neurocysticercosis (Escobar, 1983; Fleury et al., 2003, 2006, 2010) but muscular, subcutaneous and ocular forms have also been reported. (Larralde & Aluja, 2006)

The disease is found mainly in countries where poverty prevails, hygiene is lacking and people live in close contact with pigs.

In Mexico the disease is present in marginated rural areas of the southern states, (Guerrero, Oaxaca, Puebla, Veracruz, Tabasco, Yucatan, parts of Morelos and others) where the above mentioned conditions exist and the parasite encounters a favorable environment for its survival. Many of the inhabitants of these areas are extremely poor, their dwellings are made of reed, wood or other cheap materials available in their region. Their number is calculated to be 47,190,000 million (INEGI 2009; CEPAL 2010). Few hamlets or villages have piped water and get their supply from wells that may dry up during the hot season or from ponds where rain water accumulates. Donkeys frequently bring water to isolated dwellings in 20 liter containers of which they carry four. There are villages where water is rationed during the very dry months and people get one bucket per day.

Roads are rarely paved, and many become impassable during the rainy season. Children often have to walk long distances to get to school and depending on the weather and road conditions do not go, some barely learn how to read and write. In many of these remote areas the inhabitants speak their indigenous languages, have difficulties understanding Spanish, and an interpreter is needed to communicate with them.

People usually own a few animals and some land, where they grow corn, the harvest being barely enough to feed their family. Their animals, a few cattle, pigs and chicken receive very little care, and in particular the pigs roam about freely searching for food (Copado et al, 2004).

Some peasants keep their pigs confined, tying them to a tree or in primitive enclosures during the time when the corn grows.

In some of the bigger villages, health centers may be found, where people get rudimentary medical care but in the smaller ones where none is available, they mostly rely on their ancestral remedies, among them herbs and medicinal plants.

Hygiene is understandably one of the big problems for people who live under these conditions of extreme poverty and scarcity of water. Toilets do not exist in many villages and hamlets and people defecate in the open. The health authorities have made efforts to improve hygiene and have introduced latrines, but this has not been accompanied by the necessary control and follow up interventions, with the result that they are not used and are transformed into store rooms, or are built on inadequate grounds and spill over with the torrential rains.

The pigs, being coprophages, roaming about freely in villages and fields to find their food, and receiving very little attention from their owners, ingest the human feces, which constitute an important addition to their diet (Aluja et al. 1987; Acevedo, 1989; Aluja & Villalobos, 2000; Copado et al., 2004). If the owner keeps his pigs confined in yards next to his dwellings, the animals may have direct access to the outlet of a latrine and consume the feces. If the feces come from a *Taenia solium* carrier, the pig becomes infected and develops cysticerci in its tissues, predominantly skeletal muscles and brain. Occasionally people also ingest eggs which may come from contaminated food or by way of autoinfection if they themselves are the *T. solium* carrier, in which case they develop cysticercosis, mostly in the form of neurocysticercosis. (Escobar 1983; Villagran & Olvera, 1988; Larralde & Aluja, 2006, Aluja 2008)

If human beings eat insufficiently cooked meat of a pig with cysticerci they develop *Taenia solium* in their intestine. (Quiroz 2002; Larralde & Aluja 2006)

Another problem and the reason for the continuation of the Taeniosis-cysticercosis cycle in these remote areas, is that slaughter houses where meat inspection is carried out do not exist. There may be places where animals for meat are being killed, but the methods and the hygiene are unacceptable and meat is not inspected. Animals are mostly slaughtered by their owners for family or other festivities and are consumed without any inspection.

The prerequisites for the continuation of the *Taenia solium* cycle thus are:

- People who live in conditions of poverty,
- Lack of toilets or latrines,
- Scarcity of water,
- Lack of education,
- Rambling pigs.
- *Taenia solium* carriers.
- Absence of meat inspection.

These conditions still can be found in many of the developing countries, among them Mexico. (Molinari et al, 1983; Sarti et al. 1988; 1992; Larralde et al 1992; Martinez et al. 1997; Aluja et al 1998; Morales et al. 2006; 2008)

The Ministries of Health and Agriculture in Mexico issue monthly reports with information on the diseases in human beings and animals that are diagnosed in the country. Cysticercosis in pigs and human beings and taeniosis in people are nowadays rarely reported, which has led to the believe that they are practically extinct in the country (Flisser et al. 2010). The explanation for this is that, as has been described, because of the absence of medical and veterinary personal in the areas where it occurs, it is not notified. Pigs are not

slaughtered in official establishments, and health care for the inhabitants does either not exist or is rudimentary with the result that neither enters the official surveillance system.

Nine million four hundred thousand of the total pig population (15'107,785 (SIAP-SAGARPA, 2009; Rodriguez Licea & del Moral Barrera, 2010) in México belong to highly technified and controlled farms where *Taenia solium* carriers and cysticercosis are not found. The meat of these animals proceeds from strictly controlled federal slaughterhouses and cases of pig cysticercosis are almost never seen. These are the animals that enter the official statistics. The rest, 5'600,000 pigs belong to semitechnified farms and to the free roaming group, the latter being estimated around 3'000,000 pigs. (Rodriguez Licea & del Moral Barrera 2010).

By doing serological tests (ELISA) both in humans and in pigs, it was found that the prevalence of positive reactors is rather high in those states of Mexico where the above conditions are found, both in human beings (Larralde et al. 1992) and in pigs (Sosa, 2010; Sciutto [in process]).

Tongue inspection of rural pigs confirm the presence of cysticercosis in marginated areas. In a remote region of the state of Morelos, the prevalence of porcine cysticercosis ranges between 4 and 33%. (Morales et al. 2002). In the state of Guerrero it has also been shown in some villages that the frequency is high (Molinari et al. 1983; Keilbach et al., 1989; Martinez et al. 1997; 2000) and in recent unpublished data it was found to range between 0 and 13,5%.

Official data on the frequencies of neurocysticercosis and teniosis in human beings in the country have not been published. As has been pointed out, methods to diagnose cysticercosis in the population are not available in isolated regions. During conversations with people in villages, one may hear of a relative who gets epileptic fits or another one who suffers from intense headaches, both among the symptoms of neurocysticercosis (Ortiz et al. 2006). However, in the absence of diagnostic tools and in view of the fact that the financial means to travel to the city are lacking, these cases remain undiagnosed. In a recent study Fleury, using computerized tomography found that in a rural community of the state of Morelos the frequency of neurocysticercosis was 9,6% (Fleury et al. 2006) and the same author reports that in hospitalized patients in a neurological institution it has remained unchanged during the last 10 years (Fleury et al. 2010).

Evaluating all these factors, a group of Veterinarians, Immunologists and Neurologists of the National Autonomous University of Mexico (UNAM) and of the Institute of Neurology of the Ministry of Health considered that, *T. solium* teniosis-cysticercosis, still being an important disease in parts of Mexico, a programme to control it is needed. One of the reasons that justifies this is that neurocysticercosis is being reported again in the United States of America (USA) and that most cases are traced back to Mexican or other Latin American immigrants (Sorvillo et al. 2007; 2011).

Isolated interventions to control the zoonosis have been carried out in Mexico and elsewhere, but to our knowledge none of them considered follow up activities (Sanchez et al. 1999; Keilbach et al. 1989; Sarti et al. 1997; Boa et al. 2003; Eddi et al. 2003; Engels et al. 2003; Martinez et al. 2003; Pawlowski et al. 2005).

Among the methods to control teniosis-cysticercosis, several strategies have been proposed, like improving infrastructure for sanitation, confinement of pigs, the obligatory installation of latrines, regular antihelmintic treatment of the population, treatment with albendazol of infected pigs, obligatory meat inspection, health education and quite sophisticated measures like meat irradiation (Larralde & Aluja, 2006; Flores et al. 2006).

Most of these proposals cannot be introduced on a short term basis under the conditions that still prevail in those areas where the disease exists. The health authorities offer antihelminthic treatment to adults and children, however the doses they prescribe may not suffice to eliminate taeniae. The suggestion to treat infected pigs is not practical, as it is not possible to inspect all free roaming animals to find the ones with cysticerci and besides, owners would have to wait at least 3 to 4 months before they can sell them for slaughter, in order to eliminate the remnants of the larvae from the muscles.

Integrated into our control programme we decided to use vaccination of pigs.

Vaccines against cysticercosis, both pig, cattle and sheep have been employed in other countries and in México (Johnson et al. 1989; Plancarte et al. 1999; Huerta et al. 2001; Flisser et al. 2004; Sciutto et al. 2007; Harrison et al. 2005; Gonzalez et al. 2005; Assana et al. 2010). The vaccine S3Pvac that we use in our control programme is produced in the Institute for Biomedical Research of UNAM. It contains 3 protective peptides: KETc12 of 8 aminoacids, KETc1 of 12 and KETc7 of 110. (Manoutcharian et al. 1996; Manoutcharian reference 2004; Rosas et al. 1998; Toledo et al. 1999; 2001) In the peptide KETc7 2 protective epitopes GK1 and PT1 of 18 and 10 aminoacids respectively were identified (Manoutcharian et al. 1999). These peptides belong to different developmental stages of *Taenia crassiceps* and *Taenia solium* (Toledo et al. 1999; 2001; Rosas et al. 1998, 2002; Sciutto et al. 1995, 2007, 2008) and are found in different anatomical structures of the cysticerci, in the eggs and in the adult taeniae. Their sequences are detected in both cestodes with minimal differences in certain aminoacids which do not modify their tridimensional structure nor their protective capacity (Rassy et al. 2010).

The first version of the vaccine, S3Pvac, was evaluated in an endemic area in the state of Puebla (Huerta et al. 2001). It reduced the number of infected animals 50% and 98% the number of vesicular and colloidal cysticerci that are capable of developing into the adult worm.

The second version was the recombinant vaccine S3Pvac-phage, which consists of the SP3vac peptides which are expressed in filamentous phages. It was evaluated in communities in the state of Morelos and reduced 54% the prevalence of porcine cysticercosis and 89% the number of established cysticerci. (Morales et al. 2008)

In order to plan a programme with possibilities of success one has to consider all the factors that contribute to the persistence of the zoonosis and which have been enumerated above.

We selected communities in the state of Guerrero, where we had detected a high prevalence in the marginated areas, to start our activities.

The first task was to inform and convince federal and local authorities of the need to include the control of this zoonosis in their official health programmes. This was achieved by underscoring that the disease continues to be a health issue in areas where poverty prevails and that due to migrant workers it has spread to other countries.

The project was well received and the authorities collaborated by facilitating funds to purchase a vehicle to transport the members of the teams and to pay for their travels and salaries. They also authorized funds to purchase ultrasonographs for the diagnosis of porcine cysticercosis. This method has proven to be reliable and easier for both veterinarians and pigs, because it eliminates the often cruel handling of pigs and the strenuous efforts of veterinarians and assistants to immobilize them. (Herrera G. S.C. et al 2007)

Before we started with the activities the village authorities, teachers and peasants had to be informed of the programme, by explaining the cycle of the parasitosis, the consequences of getting neurocysticercosis, and the loss of income if their pigs acquire cysticercosis.

Teams are formed of at least one veterinarian who is responsible for the activities of the group, last year veterinary students who vaccinate and volunteers, usually veterinary students who want to help and learn. People of the village are employed on a daily basis to help find, catch and hold the animals.

Other teams are trained to educate people. They give talks, whenever possible with audiovisual aids, to inform children, teachers, parents and the population in general on the disease, its consequences and how to avoid becoming infected, how to keep their pigs and the importance of using latrines and how.

The strategy we follow in our programme to control the disease is twofold:

1. Vaccination of pigs
2. Education of the population

2. Vaccination of pigs

After having agreed upon the day of vaccination, the owners keep their pigs confined and their tongues are examined by members of the team and each animal is registered in a data base, appointing the name of the owner, his or her address, age and sex of the animal, and where it was borne. All pigs are then vaccinated. If cysticerci were detected in the tongue, the pig is carefully examined with ultrasonography and if found positive, we try to purchase it from the owner. An attempt has been made to exchange it for a better bred animal, but this has not been very successful as these newly introduced piglets do not resist the hardship of their new lives and often die. The vaccine is applied subcutaneously, and repeated 3 times, with 3 months interval between each.

3. Education

The teams make appointments with the village authorities, with teachers, schools, parents, medical staff and nurses in order to explain how to improve their hygiene, how to keep their pigs, the importance of using latrines and other topics that may arise during the discussions. The importance of detecting a *T. solium* carrier is of course stressed and people are advised to get treatment for intestinal parasites, which the government offers free of charge in the health centers, whenever possible.

In order to determine how much people know about the disease and also what their living conditions are, before the programme gets under way, a questionnaire is distributed and people who know how to read and write are asked to answer it. The team members help those who cannot to fill it out. The same questionnaire will be distributed at the end of the project and compared with the initial one, which will show whether the educational campaign was successful. At present (August 2011) we have finished with vaccination and 3 months after the last application we shall start to examine all pigs in the communities and compare the frequency of infected animals with the one registered at the beginning.

During our work we have found the attitude of the people very positive. They are grateful for the dedication of the teams, and for the time they spend with them to show how they can improve their pig breeding methods and their own hygienic habits. The children are thrilled with the audiovisual presentations offered in their schools and go home to explain to their family what they have learnt. It is our conviction that to invest time to teach children is most rewarding, as they are more open to new knowledge than the older

generations, who often resist change arguing that “their ancestors have done it this way and why should they do it differently”.

Problems may arise identifying pigs. We ask the owners not to introduce new ones into their group during the vaccination period and not to sell or kill animals without letting us know, but this has proven to be almost impossible as some get lost or die according to the owners and others that have been added to the group. We try to identify each animal by their special colors or markings, but inevitably there are failures with this system and to mark all pigs with microchips would be too costly. The possibility thus exists that not all pigs get the 3 planned vaccinations but we hope to be able to cover the majority.

By vaccinating as many pigs as possible, we hope to interrupt the cycle of the zoonosis and by educating the population we are confident that people will acquire the habit of using correct latrines, of washing their hands whenever possible before preparing food and of abstaining from ingesting meat with cysticerci, also of building correct stalls for their pigs.

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51000 Rijeka, Croatia
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Phone: +86-21-62489820
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